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EARTH SCIENCES AS THE BACKGROUND OF HISTORY¹

By JOHN C. MERRIAM

CARNEGIE INSTITUTION OF WASHINGTON

THE LARGER VIEW OF HISTORY

THE concept of history as generally accepted has undergone extraordinary changes in recent years. History as read and taught has frequently expressed only in part the broader relations of events with a view to indicating their true bearing on the present. In its origin as a constructive science much of history was concerned with the emotional side of national propaganda, and in varying measure it has been an instrument used to promote a nationalistic spirit. Fortunately, we find many interpretations which have clearly stated the continuity of events, their real relations and significance in the world sense, and their proper trend.

Not less insufficient than the use to which history has often been put is in many instances the structure of the account presented. Continuity has not always been the fundamental factor. Descriptions of events in series, but unrelated, have at times formed the basis for discussion, and fundamental laws or scientific principles have not always played an important part.

Reaction against the incomplete view of historical study is in some measure due to application in human affairs of the hypothesis of evolution or development growing out of the fundamental historical sequence of geology as presented by Lyell and applied in the broad biological concept of Darwin. Assuming that man remains on a constant level, representing the type as created, human history might show indefinite fluctuations of movement; or it might be cyclic, each cycle representing approximately the same plane of development. According to the evolution hypothesis, the trend of the living world would be toward the more specialized, or more complicated, or more advanced. Although it might be cyclic, each cycle would rise to a

¹Delivered as the Presidential Address before the Geological Society of America, December 29, 1919.

higher stage, and the path would be helicoid. According to the developmental or evolution interpretation, every part of a historic sequence is related to every other part, and each feature of past series contributes somewhat to the interpretation of the present. This concept gives us for every portion of historic succession a formula, through which, with a certain degree of accuracy, the line may be projected forward. Viewed in this light, history becomes not merely a teacher by comparison or by analogy, but interprets the development of present conditions, and also furnishes a key to the future.

Rarely has the range of historical account included all major influences actually involved. Largely by reason of the fact that the world is so complicated, there is no connected statement which shows the happenings as a whole with their interlocking connections. The records are mainly pieces, or pieces of pieces, limited to one phase of the subject, restricted to one portion of the world, and covering only a small section of time. True world history scarcely exists.

Analysis of the elements composing the fabric of history, considered in its enormous complication and as a world problem, shows that we cannot doubt the need for every item of knowledge which may be brought to bear for interpretation of our present situation and requirements. We must have these materials also for guidance of mankind in decisions on those greater problems demanding for their proper settlement a vision reaching over long periods and extending beyond the present generation. We should have light with increasing brilliance thrown into many dark corners.

Present world questions will be solved in part by men who trade and those who study commerce, in part by men who rule and those who study ruler and politician. But the only view that can show us where we are and whither we go is one that, with other items, includes at least the outlines of the path over which we have come.

The point of my story in this paper is that the farther back we see the path clearly, and the better we know our progress over it, the more certain we are to eliminate the minor curves and determine the true direction and the rate of speed to expect.

I am suggesting that the deepest view of history is desirable for the purposes of fundamental decisions; that, no matter how far back this vision leads us, if it continues to add to knowledge of what we are by showing us how we came to be, it is needed and should be secured.

CONTRIBUTION OF THE SCIENCES TO HISTORY

The sciences especially concerned with historic sequence are astronomy, geology, geography, paleontology, biology and anthropology. Astronomy, with its broad conceptions of stellar evolution, concerns us because it discusses the origin and early history of our planet. Geology

and geography deal directly with the earth. Paleontology, representing biological history, must go to geology for its record. Anthropology has, as one of its most important phases, the history and origin of man.

The field of the astronomer, with its myriad bodies of the heavens, presumably represents wide range in development of the stellar systems within our view. Yet, with all our information as to the stages through which these bodies may proceed in their history, there is but little positive evidence on which we may depend. We may note modifications in the surface of the sun or in the clouds of Jupiter, or we may observe the varying brightness of the stars; but there is little in these variations which we have proved to be more than incidental fluctuation. Our knowledge of evolution of the stellar universe must depend largely upon comparisons of stars of various types, or of groups of stars and nebulae which we assume to represent incipient stellar systems. The nebular hypothesis, which has served to present a type of evolution of the solar system and a basis for interpretation of the origin of the earth, is called in question to such an extent as to be no longer acceptable to a large group of astronomers. The planetesimal hypothesis, developing similar world systems out of spiral nebulae, seems also to suffer under recent criticism. For practical comparisons in study of world evolution, we appear to have one of the most important sources of information in the history of our own planet. For the universe in the large we can prove little more than that there is shown a process of development for which almost infinite time seems required and in which cycles seem determined.

Our greatest scientific contributions to the study of history and of origins have come through geological and biological investigations. Geology is the greatest of historical sciences. From comparative and experimental studies alone biology makes large contribution, but its distinctly historical phase lies in the field of paleontology, in which the life record is read from the geological book. To geology and biology, furnishing together the life records, anthropological history must be added, reaching back, as it does, into geological history and expressing the beginnings of our account of human life and activity in terms of geology and paleontology.

For the purposes of this paper, geological history may be divided roughly into two portions. One, the later division, is represented in the known section of stratified rocks formed through the piling up of sediments and by the out-welling of molten material spread on the surface or squeezed into the strata. An earlier period expresses in a more doubtful manner the partly astronomic history of the earth antecedent to the record presented by the lowest or earliest known strata.

The astronomic period of our earth's history is a subject for investigation by astronomer, physicist, chemist, and geologist. As yet the results of studies in this region are in large part of a speculative nature. The field furnishes one of the most attractive opportunities in science for further investigation. Although this phase of the problem has in it very much of fascination, the results are still of such a nature as to contribute little toward the objects of the present discussion. I shall therefore refer to geologic history only in terms of the distinct record extending to the lowest known strata in the second chapter of the account.

The length of the period which remains after elimination of the earlier or astronomic stage may be very short measured against the total age of the earth. We know that the lowest strata, wherever we find them, rest upon rocks which have been molten and in their molten state have destroyed the basement upon which the oldest known stratified rocks once rested. We admit, therefore, that not only have we lost the record before the earliest strata were formed, but that the earliest strata themselves have disappeared. The record remaining is, however, by no means brief in terms of human understanding. Few recent estimates have suggested that the section comprises less than two hundred thousand feet of strata, or that the time involved measures less than one hundred million years. This time may not be long compared with the entire age of the earth, and may not be more than a moment compared with the age of our solar system, but it furnishes all that we require for purposes of interpretation of human history.

Reduced to their simplest terms, the geological data of the stratified rocks give us a history relating to the accumulation of sediments, movements of the earth's crust, the making of continents and ocean basins, erosive agencies tending to wear down the land, volcanic activities, climatic changes, and life succession. This history presents, as its first significant lesson, the fact of instability of the earth's crust and the evidence that throughout geologic time, as we know it, the surface has shown diversity of form dependent upon movements of large magnitude. By offering opportunity for erosive forces to act, the movements which have produced continents and mountain ranges have also been responsible for accumulation of the sediments washed down to form the strata from which our record is read. Also intimately related to the succession of crustal movements is the history of igneous activity evidenced from time to time in the great extrusions of molten material forming successions of lava flows intercalated in the sedimentary series. The history of climate, furnished us through a great variety of data, gives evidence of almost continuously fluctuating conditions in the physics of the atmosphere, ranging between high and low humidity, and between temperatures comparable with those of the glacial periods and the climate of tropical or subtropical

regions of the present day. The salient features of climatic history are the continuous change and the evidence of comparatively slight range of temperature for the earth as a whole within the span of geologic time as known.

Earth history, as we see it in this record, shows from the most remote periods to the present constantly varying surface conditions dependent upon an unstable crust; continents and mountains arise only to be subject to the steady grind of erosion, wearing them away and spreading the débris over the seas. Always do we find land areas and seas, but with much variation as to size and form; always was the temperature near that of the present, though fluctuating from warmer and more humid to climates like that of the Glacial Period.

Within the whole span of geological history and its continuous changes recorded, the phases of purely physical history presented do not show us in any of their various aspects definite progression or trend which may be described as an evolutionary process. It was once our practice to place emphasis on the geological history of the earth as the continuation of a graded or evolution series based on the succession of stages described in the nebular hypothesis. According to this view, we seemed to see in climatic evolution a gradual movement away from the conditions of the primitive heated earth and toward the present temperature of a cooling sphere. We once thought we saw the early atmosphere fit only for lower organisms and later cleared and purified for the higher types of life. With better understanding of climatic history, it comes out more and more distinctly that while the earth's climate fluctuated continuously, there is no clear evidence of definite progression through a series of stages dependent on gradual cooling of a once highly heated globe.

So in other phases of purely physical history we have worked out what seemed at first to be evolution series, which have all proved finally to be nothing more than cycles that may be represented by variable formulae. As nearly as we can determine, the physical history of the earth within the span of time represented by our legible record has been so nearly stabilized as to show little or no variation which may not be considered merely as fluctuation rather than as evolution.

As evidence of a continuously changing evolution series, the most extraordinary record of all history is that included in the paleontologic succession of life, running down through the story of geology, practically to the beginning.

Not only do we find the character of the earlier stratified rocks indicating atmospheric and climatic conditions similar to those now obtaining on the earth, but we find the rocks containing traces of living forms such as now are fitted to these climatic conditions. Throughout the whole stretch of the strictly geologic record, conditions in temperature and humidity evidently kept within the range

permitting development of living forms. The period in which life came to be on this earth is represented by a chapter now obliterated.

The life record is, to be sure, fragmentary, but in many groups it is extraordinarily full. Although there is much to be desired, out of the long series of events certain features in the evolutionary sequence are so clear as to be unavoidable. We find this record showing: (1) that life has been in almost continuous state of change. From top to bottom of the geologic section, in no two great groups of strata do we find that the assemblages of living forms represented are the same. (2) We know the life of each stage to exhibit closer resemblance to that found in strata immediately above and immediately below than to the life representation of the more remote divisions. And (3) we note that the series of forms with certain common characters, but differing in grade of specialization, generally trend toward greater specialization from earlier toward later time. The way in which the changes in living forms took place from age to age may not always be evident, and the paleontologist may admit his ignorance of the causes, but the fact of more or less rapidly changing, definitely specializing series of presumably connected or related types seems reasonably clear. The evidence, taken in its entirety, furnishes strong support for the view that the life of each stage is derived or modified from that of a preceding stage, and that the whole series indicates the continuity of life from earliest to latest time.

Unlike the sequence in purely geologic history, we have in the paleontologic succession continuity with progress in a definite direction. We have, however, noted that there is probably close relation between the continuous change of the progressing living world and the fluctuations in condition of earth climate and earth crust. Movements of the crust producing change of topography and variation in distribution of land and water, taken with changes of climate, must have had important influence in keeping the currents of life moving. A dead earth, without crustal movement and with uniform climate, might have limited greatly the possibility of biological evolution. The fluctuations in physical conditions on the earth in geologic time have, therefore, great significance in consideration of the larger problems of earth history.

It is not my purpose to bring into review, or to discuss, the tremendous field for evolutionary studies in the history of groups of animals and plants whose records we find preserved in the rocks. One after another these series have been considered by specialists in various fields. In all cases, the laws of which I have just spoken find expression, whether this be in the evolution of nautilus, dinosaur, or elephant. Given lapse of time and change of environment, and the old goes out, the new comes in, the unspecialized gives way to the specialized. As the ages go by, in each successive step, almost without

exception, we find a higher level of life, representing greater intelligence, greater efficiency, and greater progress.

The most interesting of all the series of fossil forms represented in the geological record, and particularly interesting in the first instance because it begins well back in past time, is that succession giving us the beginnings of the race of man. The earliest known traces of human beings represent a normal part of the life of the earth in a period so remote from the present that our calculations must be in terms of eons rather than of millennia. We find that since these first man-like forms appeared great crustal movements have changed the face of the earth, and that the climate has shifted back and forth many times through relatively wide ranges of temperature. We know also in this period a long procession of living generations of animals other than man passing through the ages and disappearing.

We find the first remains of humans more beast-like than any living race, approaching the ape-monkey group in many characters, and meeting the requirements of the missing link. We find this first stage followed by others still different from man of the present day, but approaching more nearly to the modern type. The laws applicable to the evolution of other groups apply to man. We note the same relation of physical change in man to lapse of geologic time, to climatic and crustal change, and to other factors in the history of the earth. So far as the evidence goes, it meets the requirements of those who assume the emergence of man from the animal in the manner in which innumerable other organic types have arisen in the long life record as we know it.

Through still later stages of the geologic and paleontologic record man advanced in intelligence and culture, his environment gradually approximated present conditions in both physical and biological factors, and we record the history of these stages partly in terms of archeology, which in turn merges into history based on written records.

Through the evidence of archeology, paleontology and geology we see human history extended back stage by stage until we go from history to prehistory, where in ages remote and in environments strange we find man already widely distributed over the earth, varying as to kind and culture and advancing as to ideas. With this view there seems no escape from recognizing that not merely the foundations of history, but the greater part of the human span, falls within a realm the approach to which has been largely by investigators concerned with the problems of earth science and using the methods developed for this field of study.

The present paper is addressed to the relation between this material, obtained from the earlier segment of history which has been briefly outlined, and that which comes within humanistic study based on modern man. You may perhaps urge, as in Huxley's remark con-

cerning the significance of information obtained through a "medium," that, whether or not we are truly dealing with "a message from beyond," there may not be in what we learn anything worth attention. It may be thought that remoteness means by definition diminution of value and interest, and that events of ancient history diminish in importance as the square of the distance, or at a more rapid rate. At present my only answer would be that what is first is commonly, if not always, fundamental, though fundamental characters may be overshadowed by superficial.

It is not my purpose to give detailed illustration of present and future use for the facts of history seen in outlines of the longer span secured by study of earth sciences. I may, however, set forth one or two examples.

Of the many elements in the problem of world government which now confronts us, there seems to me every reason to believe that race as a fundamental factor is inferior to no other involved in consideration of unity in organization. Assuming that culture, speech, economic interest and political organization may temporarily overshadow it, in the last analysis we may not avoid reckoning with this factor, not merely in consideration of the organization of the greater groups of human beings, but also in the relations of slightly separated types. The fact that we may refuse to consider it does not prevent its acting as a continuously operating element, which remains while prices go up and down, political parties come and go, and national units group themselves in this way or that.

Race is the product of evolution in a changing environment the conditions of which have been determined by factors of geological significance. As a relatively simple illustration, the history of the original Americans is a tangled web in which is inextricably woven the story of great continental and climatic changes and of vast inter-continental migrations of plants and animals. The history of European and Asiatic races is of like order. The relation between Africans and Caucasians or between Africans and Mongolians is dependent on similar conditions reaching into remoter periods and still more difficult of interpretation.

The Balkans represent the fault-line of Europe, because this is a region of overlapping races and subraces, conditioned in their history by extraordinarily complicated migrations determined and directed in part by physical features and climatic changes. Although the Balkans present a problem of the greatest difficulty in the racial and political sense, they place before us a study simple of aspect and significance compared with the larger race questions which we shall encounter in consideration of world government. The difficul-

ties of this problem we shall not improbably see in larger measure as the centuries pass.

Shall we, in attempting to solve these incalculably complicated questions, look only at the present balance of trade, the dominance of particular political parties, the present grouping of social elements, or the present military strength of the nations involved; or shall we, realizing the vastness and the complexity of the difficulty, bring to the light every element concerned, scrutinizing with especial care those factors which seem to be fundamental and more clearly of permanent significance? Unless the larger or broader view is taken, I feel that we shall fall short of the interpretation of humanity needed in order to fit the nations of the world together into one great unity in which each people supplements the needs of the others, and thus gives to every group, as well as to every individual, the freedom to develop its own peculiar talent and grow into that fullest usefulness which we assume to be the natural right of all.

The question of race just described is only one phase of the historical problem in which the background represented by earth sciences becomes of real significance.

In passing, I may mention only two other examples illustrating the relation of historical data from earth sciences to affairs of life of to-day. I believe I am correct in stating that earthquakes are by most persons considered as extraordinary happenings, without relation to the normal order of events with which we have acquaintance. The geologist, however, recognizes them as the natural corollary of crustal movements. Regarding the continuance of such movements, he must believe that the only basis for considering that crustal activities have ceased is to assume some extraordinary intervention definitely holding back forces which if unfettered would result in further crustal disturbance and in earthquakes. Such disturbances have affected the earth since the beginning of our geological record. The geologist who views the history of crustal movement considers that there is no reason for believing that the crust is now stabilized, and assumes that we may expect other movements and other earthquakes. We know fairly the physical laws that govern earthquakes. We can prepare to meet them in such a way as to eliminate most of the dangers incident to their action, but it will take the passing of another generation before we reach a stage in which the clear lessons of earth history bearing on interpretation of these phenomena will become the basis of common practice, such as dictates the precautions which have made it possible for us to build in summer against the rains of autumn and the snows of winter. Many of us still build as if the last earthquake suddenly ended the series measuring back for tens of millions of years.

Still more difficult may it be for us to make use of the lessons of pre-historic history relating to our adjustment to biological environment. In America we live largely on plants and animals of Old World origin, not because the abundance of these types is so much greater than that of American, but because man has lived a longer time in the Old World, and within the period of his early history, reaching back to past geological periods, he has experimented intentionally or accidentally with Old World plants and animals for a longer time than has been given to contact with the native life of America. There are many who do not recognize this relation to the world of undomesticated organisms about us, and seem to feel that some plants and animals were predetermined to domestication, while others can never serve us.

Left to chance, as during the past millenniums, we may in time develop a series of useful American plants and animals corresponding to those of the Old World; or, recognizing the significance of the historical explanation of our relation to domestication, we may be active and carefully directed research secure results comparable to those of a long period of casual or accidental contact, and obtain a great variety of wild forms for use to meet human needs. Such an example of possibilities seems to be found in the development of the desert rabbit-brush as a source of rubber. An investigation was undertaken as an emergency problem during the World War, when there loomed before us the possibility that submarine dominance would eliminate all possible rubber importations. Recent studies by Hall and Goodspeed have shown the presence of 300,000,000 pounds of rubber in the desert region of the West. At present prices it is not available. In an emergency it might be a factor of first importance contributing to defense of the nation. Future research may also show possibility of large use of this supply through cultivation of the wild stock, thus making the desert an important area of production.

History shows us that sufficient understanding of the natural world about us brings large contribution to human comfort and efficiency; but, in spite of the lesson before us, many feel that the day of discovery of species most useful to man is past.

Returning to the larger view of our problem, the value of ancient history depends on our breadth of interest. If we are to deal only with matters of limited personal or national significance, only for immediate ends, and without reference to other generations; if our democracy is circumscribed in space and time, then lack of perspective and of fundamental laws in history may not be felt. If, on the other hand, we see the impending necessity of full understanding of the world's needs in their present relations and future complications, it behooves us to increase the range of human knowledge and of our comprehen-

sion of all factors entering into the problems. To most of us it appears that these great questions require the widest and deepest possible range of human understanding and the labor of generations for their satisfactory adjustment. The world statesman of the future must not only be trained to larger and higher vision, but he must have available an organization of knowledge perfect in its simplicity and infinite in its detail, covering every interpretable phase of the intricate human problem. As we approach the assembling of the data required we recognize at once the limits of the human mind and of human life, and accomplishment seems realizable only through operation in an altruistic democracy, making possible intellectual co-operation covering a wider range of experience than can be available to the individual mind.

If, in consideration of the larger problems suggested, we assume that man was created as we find him and destined to no higher plane, the sequence of history is of little value. If, however, the evolutionary view of life be correct, the continuity of history becomes of great importance, and origins, however far back, interpret the present. Should we recognize man as the product of a long series of changes determined by laws laid down in the record of earth sciences, we would have reason to consider every fact in his history as bearing on his present situation. In this interpretation of the record we view history feeling assured that nothing on the earth or in life stands still, and that the movement means continuous lifting of the plane to the more complex and more progressive.

In the lines which have been read it has been my purpose to indicate the extension of history backward into the earth sciences, and to point out the significance of this sequence as a continuity presenting in its formula an expression of the present. One may not leave the subject without referring also to the possibility of extending this continuing series from ancient geologic time into the future through a span comparable to the past we know.

To one who views the story of the world as presented through the medium of the earth sciences, it must seem unnatural to conceive of the physical and biological forces now in operation as ceasing to act before lapse of many periods like those which we have viewed. Unless there intervenes some extraordinary force beyond the reach of our understanding, the laws which have so long defined the course of nature must continue operation. Without the addition of any power beyond the spring of action furnished by laws now working, the clock of the universe must go for almost infinite ages.

Just as we are not able to conceive of crustal movements ceasing so long as we are subject to physical forces like those now controlling nature, so when we visualize the history of life in the broadest sense

we are unable to understand how the biological world, if it continues to be, and if it continues in the environment of physical change, can do other than go on to greater extremes of specialization, to greater range of complication, to greater comprehension, and to greater intelligence. If man of the future continues to maintain the relation between mental and biological which has obtained in the past stages of his evolution, there is reason to believe that he may reach to heights of mental ability, of comprehension, of intellect, of understanding, greater than those yet known. What the ultimate goal will be no one may yet see; without fundamental change of governing laws, the movement must go on.

THE GEOLOGIST'S RÔLE OF INTERPRETER

One does not expect a geologist to state his views in philosophy or in phrases aiming at the deeper human understanding, and yet there seems reason for feeling that the wider outlook of science in all of its aspects lifts us up to the identical viewpoint from which the philosopher and the poet obtain their comprehensive vision. Unlike the philosopher we do not reach backward to explain the origin or forward to interpret the ultimate purpose of Nature; nor can we, like the poet, picture in words with fullness of meaning the view which opens to us; but the type of landscape spread before us and the training of the eye which sees it give to our picture a measure of reality which its stupendous magnitude does not lessen.

Of all favored men the geologist and paleontologist see the panorama of the past unrolled in clearest reality. To them the life record is not written in doubtful hieroglyphs and symbols. It represents the imprints of living feet that have never ceased to advance in unbroken procession over a trail that winds upward through the ages. From one glimpse at footprints on these sands of time, a poet, in the person of Longfellow, gave to all generations a Psalm of Life, which has found response in an ever-widening circle of human hearts. Longfellow's poem, suggested by the antiquity of the print of a foot upon the Connecticut sandstone, was based upon a splendid lesson of analogy. He emphasized for us the idea that the influence of each life may reach out undreamed distances through space and time to make the forlorn and shipwrecked take heart again.

Pointing in the same direction, but of infinitely deeper meaning than the lines of the poet, is the reality of the story, the sermon, the poem which the geologist sees, and which must of necessity reach its recognition through his eyes and its expression through his voice. The footprints and the stages of the path on which they appear are to us not merely evidences of an unending influence; they are tangible proofs of progress from eon to eon which might well help a forlorn

world to take heart once more. We may not understand the method by which betterment has come, but we see the stages of its movement and realize that, whatever struggles the future may have in store, we shall always be credited with a margin of safety when we risk ourselves in the cause which makes for uplift in the truest sense.

Without assuming more than is involved in the field of his daily work, the geologist stands before the world as the interpreter of one view of great truths fundamental to human interest and belief. It was in large measure this depth of vision that stimulated Darwin to his epoch-making work, giving to biology and to the whole range of human thought his progressive evolution. The story of the Earth stands as the background out of which history emerges and against which its movement must always be projected. The world needs now, as never before, a broad and deep view of all that may concern mankind of the present and future. The student of earth sciences was once a contributor to the wider philosophy of nature and its relation to man. It may be his duty now to make sure, not only that his influence is felt in advancement of material welfare, but that he serve also to point out the lesson of the foundations of the earth and to show that strength may still come from the hills.